2014-09

Sleep Requirements for Flight Support Personnel

Johnson, Shawn C.

Monterey, California: Naval Postgraduate School.

http://hdl.handle.net/10945/43805

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

HUMAN SYSTEMS INTEGRATION CAPSTONE

Sleep Requirements for Flight Support Personnel

by

Shawn C. Johnson

September 2014

Project Supervisor: Nita Lewis Shattuck, Ph.D

Unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** September 2014	**3. REPORT TYPE AND DATES COVERED** HSI Capstone	
4. TITLE AND SUBTITLE Sleep Requirements for Flight Support Personnel			**5. FUNDING NUMBERS**
6. AUTHOR(S) Shawn C. Johnson			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB Protocol number ____N/A____.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Unlimited			**12b. DISTRIBUTION CODE**

13. ABSTRACT (maximum 200 words)

Expeditionary Helicopter Sea Combat Squadrons (HSC) operate on Navy amphibious assault ships to provide search and rescue (SAR), logistics and combat support. When embarked, the detachments are the primary SAR asset and have requirements levied upon them by NAVAIR 00-80T-106 to maintain aircraft SAR readiness postures in support of ship and embarked Marine Corps aircraft operations.

The goal of this study was to identify what impacts would occur to flight support personnel effectiveness if OPNAV 3710.7U sleep requirements were deviated from in order to meet minimum personnel requirements. The conclusion reached was that safety concerns are present when OPNAV 3710.7U sleep requirements for flight support personnel are violated to maintain NAVAIR 00-80T-106 operational requirements. The study found that worker effectiveness varies systematically with the duration of sleep interruption encountered. Minimum predicted effectiveness comes at three hours with the predicted values at two, three and four hours being essentially equal. When sleep interruptions exceed 1.55 hours, effectiveness levels drop below 70%, equivalent to experiencing a .08 BAC. A model for subsequent interruptions over the preceding days found that worker effectiveness varies systematically with the number of days between interruptions. The effect of sleep interruptions of multiple nights was greatest two days between interruptions. A minimum of four to five days between sleep interruptions is required for interruption effects to not be cumulative.

14. SUBJECT TERMS Sleep, Physiology, Aviation, Helicopter, Manning, Personnel			**15. NUMBER OF PAGES** 35
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

I. ABSTRACT

Expeditionary Helicopter Sea Combat Squadrons (HSC) operate on Navy amphibious assault ships to provide search and rescue (SAR), logistics and combat support. When embarked, the detachments are the primary SAR asset and have requirements levied upon them by NAVAIR 00-80T-106 to maintain aircraft SAR readiness postures in support of ship and embarked Marine Corps aircraft operations.

The goal of this study was to identify what impacts would occur to flight support personnel effectiveness if OPNAV 3710.7U sleep requirements were deviated from in order to meet minimum personnel requirements. The conclusion reached was that safety concerns are present when OPNAV 3710.7U sleep requirements for flight support personnel are violated to maintain NAVAIR 00-80T-106 operational requirements. The study found that worker effectiveness varies systematically with the duration of sleep interruption encountered. Minimum predicted effectiveness comes at three hours with the predicted values at two, three and four hours being essentially equal. When sleep interruptions exceed 1.55 hours, effectiveness levels drop below 70%, equivalent to experiencing a .08 BAC. A model for subsequent interruptions over the preceding days found that worker effectiveness varies systematically with the number of days between interruptions. The effect of sleep interruptions of multiple nights was greatest two days between interruptions. A minimum of four to five days between sleep interruptions is required for interruption effects to not be cumulative.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

II. INTRODUCTION

Historically, expeditionary Helicopter Sea Combat (HSC) Squadrons operate in independent detachments on board Naval Amphibious Assault ships, LHA and LHD class, providing search and rescue (SAR), logistics, special warfare and surface warfare support for both the ship and embarked Marine Corps aircraft and personnel. These detachments consist of two MH-60S helicopters, six pilots, six aircrew and 18 flight support personnel, making roughly 30 personnel in each detachment.

As a ship support asset, the detachment's schedule is dictated by the operational timeline and tasking of the ship and the USMC Air Combat Element (ACE). Due to the limited number of personnel in a detachment, and the dynamic nature of their operation, the detachment must remain flexible in its operational capability. Often SAR support is required, either airborne or in an alert condition, for consecutive 24-hour periods, which requires 24-hour maintenance support. The detachment's ability to meet these operational requirement is reliant on detachment manning, in both the domains of manpower (i.e. the number of people in the workforce) and personnel (i.e the qualification level of the workforce).

An inability to conduct maintenance with the proper qualifications and manpower, as dictated by COMNAVAIRFORINST 4790.2B Naval Aviation Maintenance Program (NAMP), is detrimental to aircraft maintenance, safety, and ultimately, will result in aircraft that are not mission capable. In manpower and personnel deficient situations, when aircraft must still be mission capable, something must be traded so that the appropriately qualified people are present to conduct maintenance as dictated by governing directive. When faced with the decision to cancel operations, violate maintenance and safety protocols, or have qualified maintainers work long or extra hours so as to be present to conduct

maintenance, the decision for flight support personnel to forego sleep is often seen as the least harmful option.

III. BACKROUND

A. LITERATURE REVIEW

A review of the Navy's instructions highlights two documents which are relevant to framing HSC detachment operational requirements and flight support personnel sleep requirements: NAVAIR 00-80T-106 LHA/LHD NATOPS and OPNAV 3710.7U NATOPS General Flight and Operating Instructions.
NAVAIR 00-80T-106 LHA/LHD NATOPS defines the mission and scope of HSC detachment operations with respect to LHA/LHD operations.

> 8.1.1 SAR Detachment Helicopter
>
> When at sea, the SAR detachment helicopter shall be maintained, during daylight hours and when operationally feasible, in Condition IV for SAR/MEDEVAC contingencies. A SAR crew shall be designated and promulgated in the air plan. The designated crew shall remain the duty SAR crew until properly relieved by another crew; brief and preflight complete. The helicopter may be utilized for local administrative, logistic, or training functions while in standby status. The embarked squadron/detachment should assume SAR/MEDEVAC standby whenever the ship's SAR detachment helicopter is not operationally ready. (Department of the Navy, 2013b)

Overall, the above requirement in NAVAIR 00-80T-106 8.1.1 stipulates that one SAR-capable aircraft must be maintained in at least Condition IV status unless not operationally feasible. The definition of "not operationally feasible" is broad and open to interpretation and the commanding officer's discretion. It is the detachment's responsibility to determine its aircraft's readiness and capabilities are within the bounds of Navy regulation.

When operational SAR mission capability is required from the detachment for various LHA/LHD operations and ACE sorties, at a minimum one aircraft must be maintained in an upgraded condition status as noted in Table 1.

Table 1. SAR Helicopter Requirements derived from NAVAIR 00-80T-106		
Operation Type	Requirements for SAR Helicopter Day Operations	Requirements for SAR Helicopter Night Operations
Multi-helo/Multi-Tiltrotor or V/STOL	Condition II or Airborne*	Condition I or Airborne
Troop Lift	Airborne*	Airborne
* SAR equipped helicopter does not require automatic hover capability		

NAVAIR 00-80T-106 defines the condition/alert status of the SAR helicopter as:

5.1.7.1 Condition I/Alert 5

The helicopter shall be spotted for immediate launch with rotor blades spread, starting equipment plugged in, and the LSE and starting crewman and ordnance personnel ready for launch in all respects. When the word is passed to “Standby for launch,” engines shall be started without further instructions; however, launch shall be positively controlled from PriFly. Aircraft should be airborne within 5 minutes of order to launch.

5.1.8.2 Condition II/Alert 15

All provisions for Condition I apply, except that flightcrews are not required in the aircraft. They shall, however, be on the flight deck near their aircraft or inside the island structure at the flight deck level.

5.1.7.3 Condition III/Alert 30

Main rotor blades may be folded and the helicopter need not be in position for immediate launch; however, it must be parked so as to allow direct access to a suitable launch spot. A towbar shall be attached to the helicopter and a specific LSE, tractor driver,

> handling crew, and starting crewman shall be designated and assigned to each helicopter.
>
> These personnel must be thoroughly briefed, so that when the order is given to prepare to launch, the helicopter can be safely and expeditiously moved into position and readied for launch. Flightcrews shall be in the ready rooms or working spaces, in flight gear, and prebriefed for the launch. Aircraft should be airborne within 30 minutes of order to launch.
>
> 5.1.7.4 Condition IV/Alert 60
>
> The condition of the helicopter is similar to Condition III, except that minor maintenance may be performed if no restoration delay is involved. The aircrew shall be designated and available. Aircraft should be airborne within 60 minutes of order to launch. (Department of the Navy, 2013b)

Often, multiple helicopter, multiple tilt-rotor, VSTOL and troop lift operations are conducted over a prolonged period of time in continuous cycles over a 24-hour period. An example of such an operation would be continuous 24-hour Harrier airstrikes into a country, amphibious landings, or large troop movements that can last for multiple weeks. In such an operating environment, requiring 24-hour SAR support, detachments must operate continuously to maintain the readiness of their aircraft. Routine aircraft maintenance must be performed on one aircraft in its off-cycle periods while the other is airborne or in an alert condition. This situation requires maintenance to be moved into a 24-hour cycle traditionally broken into a two-shift 12-hour work rotation.

HSC detachments are historically manned with one work center maintainer qualified as a collateral duty quality assurance representative (CDQAR) and collateral duty inspector (CDI), and a second work center maintainer who is an unqualified worker. In some instances, the second worker will also be qualified a CDI but this is not common. For reference, a CDQAR is fully qualified in their maintenance work center and a CDI is an intermediate qualification to CDQAR. For a detachment to have two fully qualified shifts to

conduct two 12-hour maintenance shifts over a 24-hour period, it must possess a CDI and CDQAR on each shift, which can be the same person. When this manning level is not possible, the qualified CDI/CDQAR may be tasked during their off shift period to work on the aircraft to maintain aircraft operational capability.

OPNAV 3710.7U NATOPS General Flight and Operating Instructions is an often overlooked document when it comes to aircraft maintainers as it is primarily directed at Naval Aviators and Naval Aircrewmen. Yet, OPNAV 3710.7U pertains to the framing of this paper because it clearly defines limits to maintainer's (flight support personnel) work periods and minimum required sleep periods.

> 8.3.2.1.1 Crew Rest for Flight Crew and Flight Support Personnel
>
> Crew rest is the non-duty time before a flight duty period begins. Crew rest includes free time for meals, transportation and rest and must include an opportunity for 8 hours of uninterrupted sleep time for every 24-hour period. Crew rest does not begin until after termination of official duties and is required prior to reporting for preflight preparations. Flight crew should not be scheduled for continuous alert and/or flight duty (required awake) in excess of 18 hours. If it becomes necessary to exceed the 18-hour rule, 15 hours of continuous off-duty time shall be provided prior to scheduling the member for any flight duties. Flight and ground support personnel schedules shall be made with due consideration for watch standing, collateral duties, training, and off-duty activities. Crew rest can be reduced to less than 12 hours in order to maintain a 24-hour work/rest schedule, but a shortened crew rest period (for example to maintain circadian rhythm) must always include an opportunity for 8-hours of uninterrupted sleep. (Department of the Navy, 2009)

OPNAV 3710.7U clearly delineates that crew rest for flight support personnel must include eight hours of uninterrupted sleep time for every 24-hour period. It goes so far as to say that crew rest can be limited to less than 12 hours, but must always include an opportunity for eight hours of uninterrupted sleep.

B. PROBLEM STATEMENT

Violations of the minimum eight hour sleep period do occur in order to maintain aircraft availability when a CDI/CDQAR is required during 24-hour maintenance cycles. Due to the sleep requirement and lack of two maintainers qualified CDI and CDQAR in each work center, it can be argued that HSC detachments are not manned to maintain a 24-hour maintenance posture. How effective and safe is the work being conducted when OPNAV 3710.7U sleep requirements are not followed? What is the impact to worker effectiveness when a worker is awakened on a given night? How many nights must pass before the worker returns to their baseline effectiveness level and how do subsequent sleep interruptions on preceding nights affect this recovery?

This paper quantifies the impacts to maintainer effectiveness as well as the safety concerns that result from undermanning in the domains of manpower and personnel in HSC detachments. The framework of this study is presented in consideration to OPNAV 3710.7U crew rest requirements for flight support personnel and the operational requirements levied by the NAVAIR 00-80T-106, LHA/LHD NATOPS for search and rescue support.

IV. METHOD

Data for this study was based upon ten simulated work/rest schedules which represent possible scenarios which could be encountered when a CDQAR or CDI is required to conduct or review maintenance for their work center during off shift periods. In these cases, the assumption is made that no other qualified individual is available and the work is required in order for aircraft to be operational.

A. DATA ENTRY

The Fatigue Avoidance Scheduling Tool (FAST) version 3.2.01 from Nova Scientific Corporation, located at http://www.novasci.com/, and licensed to the Naval Postgraduate School was used to conduct the analysis. A baseline analysis was conducted to establish a four-week period of shift work from 0600-1800 and crew rest from 1800-0600. A sleep pattern was established from 2100-0500 for the requisite eight hours of uninterrupted sleep. In FAST, the sleep condition was set as fair to simulate the sleep conditions encountered in naval standard berthing on an operational ship.

Ten simulations were conducted to quantify the impact to maintainer effectiveness when the eight hours of sleep was interrupted against the baseline model. The interruptions were initiated at the same time, 0000, beginning on the Monday of the fourth week and on subsequent days of that week also at 0000. The interruptions were scheduled for various lengths of time to simulate various workloads as well as on succeeding days to simulate repeated tasking. The goal of this pattern was to measure the level of effectiveness during the interruption period as well as to measure the amount of time required for the effectiveness levels to return to the baseline pattern. Figures 1-10 show the data entry for the ten simulations.

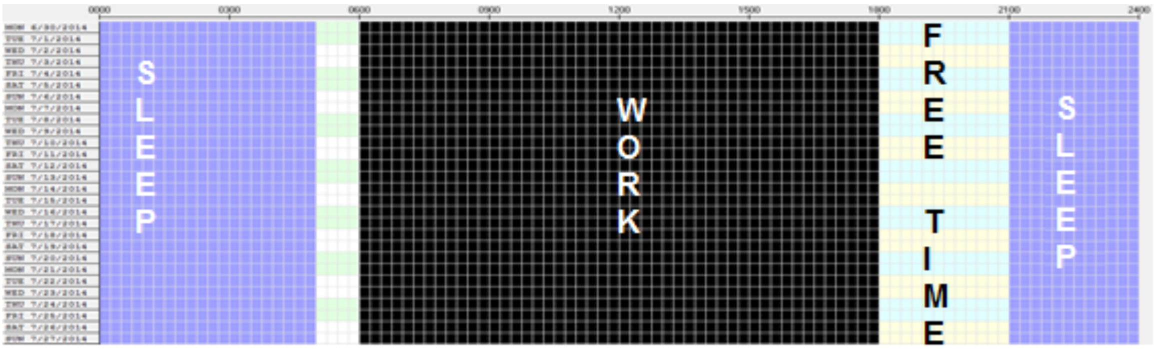

Figure 1. Simulation 1 (Baseline), 12-hour shift (0600-1800), 8 hours of sleep in fair conditions (2100-0500).

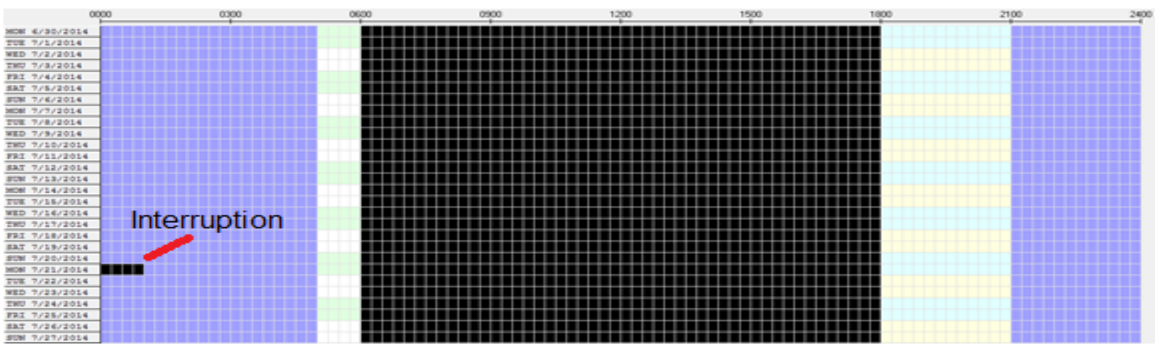

Figure 2. Simulation 2, 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Monday 1 hour awake (0000-0100).

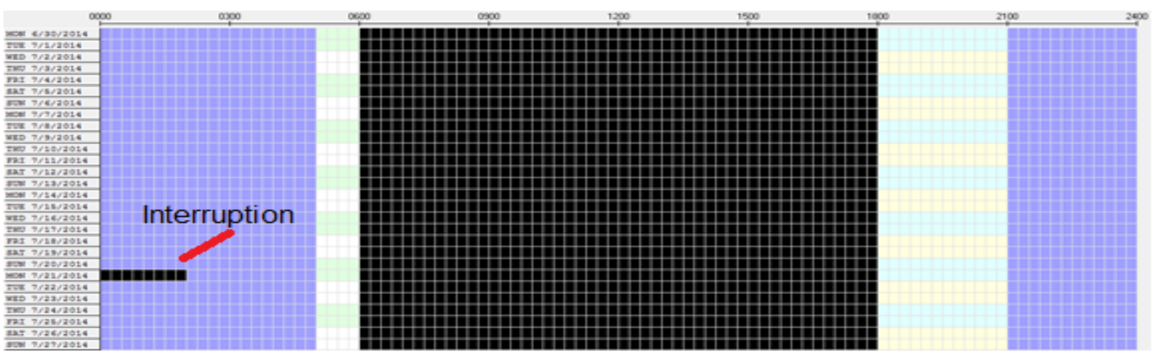

Figure 3. Simulation 3, 12-hour shift (0600-1800), 6 hours of sleep in fair conditions (2100-0500), Monday 2 hours awake (0000-0200).

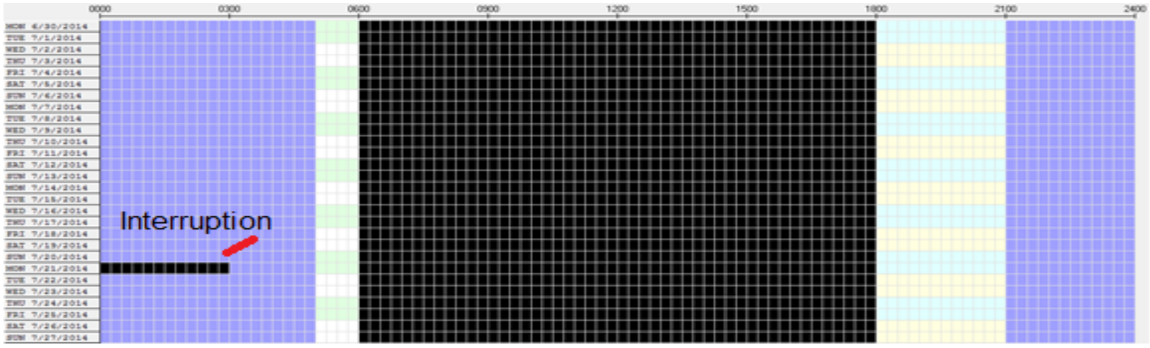

Figure 4. Simulation 4, 12-hour shift (0600-1800), 5 hours of sleep in fair conditions (2100-0500), Monday 3 hours awake (0000-0300).

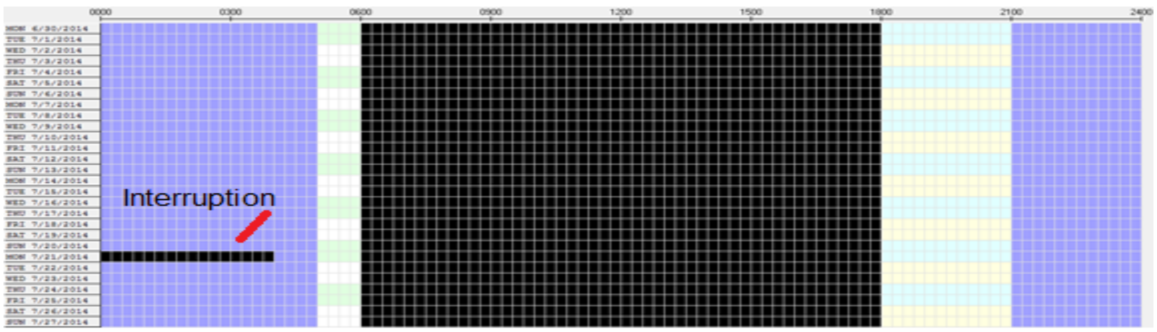

Figure 5. Simulation 5. 12-hour shift (0600-1800), 4 hours of sleep in fair conditions (2100-0500), Monday 4 hours awake (0000-0400).

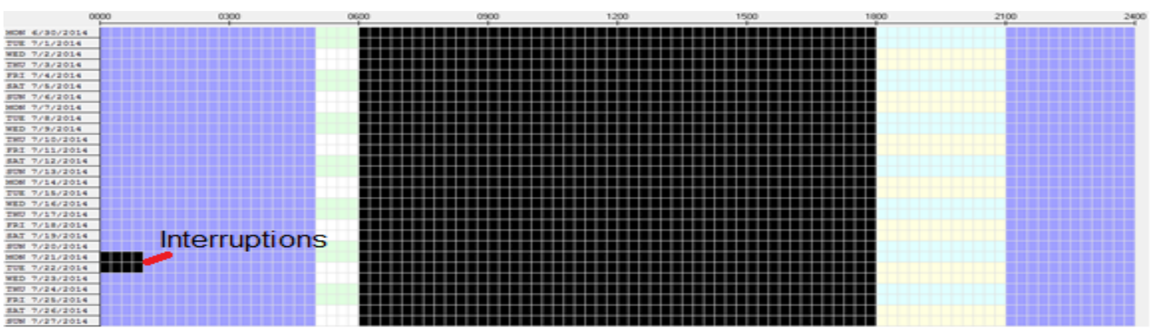

Figure 6. Simulation 6, 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Monday 1 hour awake (0000-0100). 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Tuesday 1 hour awake (0000-0100).

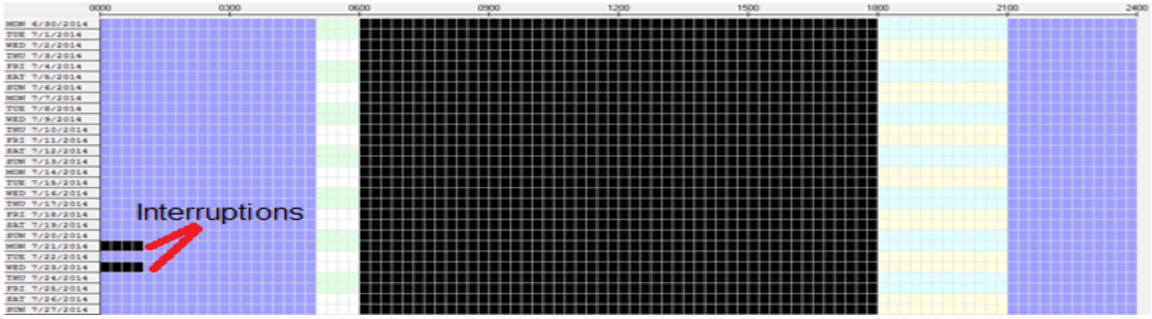

Figure 7. Simulation 7, 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Monday 1 hour awake (0000-0100). 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Wednesday 1 hour awake (0000-0100).

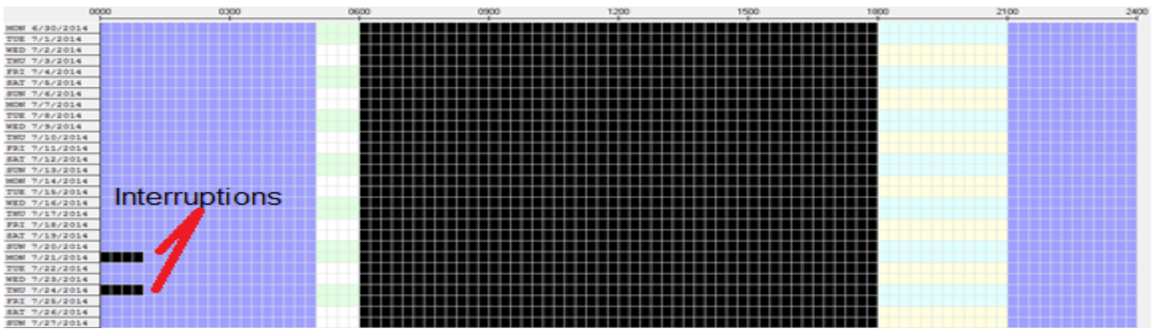

Figure 8 Simulation 8, 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Monday 1 hour awake (0000-0100). 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Thursday 1 hour awake (0000-0100).

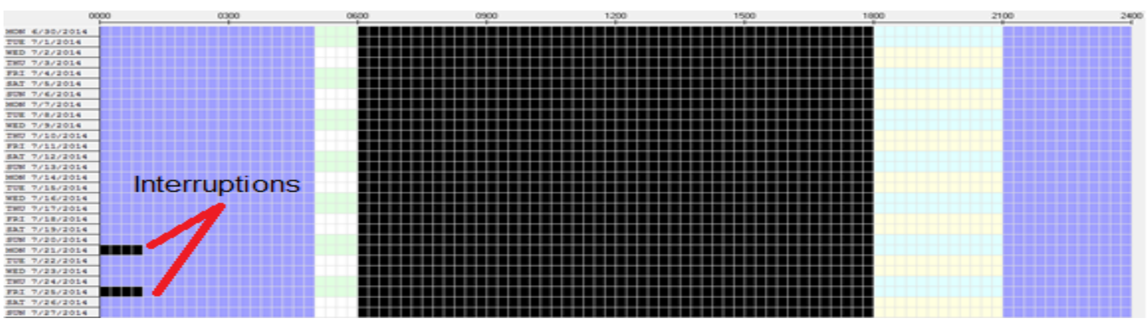

Figure 9. Simulation 9, 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Monday 1 hour awake (0000-0100). 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Friday 1 hour awake (0000-0100).

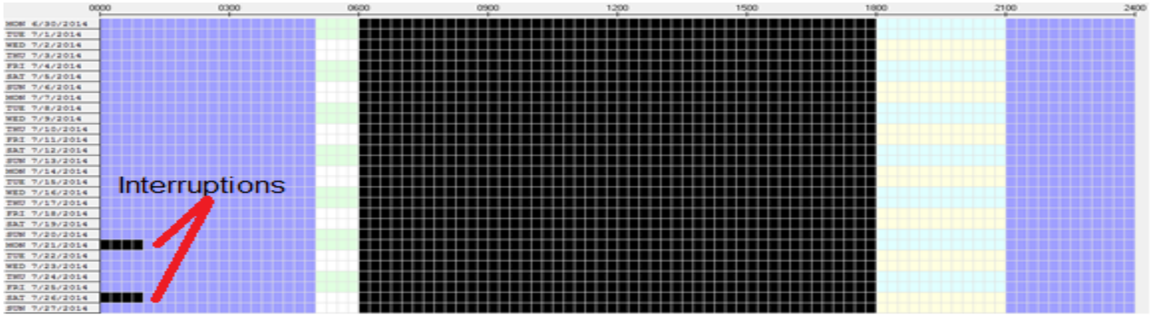

Figure 10. Simulation 10, 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Monday 1 hour awake (0000-0100). 12-hour shift (0600-1800), 7 hours of sleep in fair conditions (2100-0500), Saturday 1 hour awake (0000-0100).

Blue grids represent periods of sleep in 15 minute increments, black grids represent periods of work in 15 minute increments, and clear grids represent personal time in 15 minute increments. By creating a standardized sleep pattern over a 21 day period before the interruptions, the FAST tool stabilized into a circadian rhythm for the interruption testing.

B. MEASUREMENT PARAMETERS AND TESTING

Minimum predicted effectiveness levels were measured at the lowest point of effectiveness during the interruption period in both percent effectiveness, from the left Y axis of the FAST display, as well as in comparative blood alcohol content (BAC), from the right Y axis of the FAST display. The measured point was marked with a data marker to provide detail. The FAST Baseline display with descriptors can be seen in Figure 11.

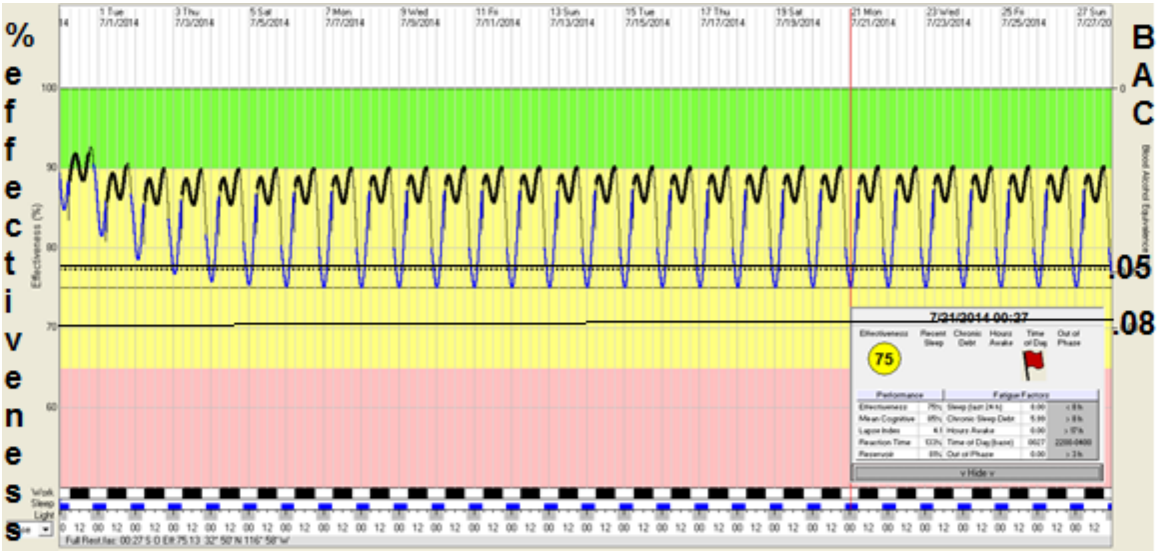

Figure 11. Simulation 1, Baseline FAST Analysis Plot with descriptors.

Minimum effectiveness levels across Simulations One through Five were analyzed in a polynomial regression to determine the amount of effectiveness drop as a condition of duration of sleep interruption. The independent variable was the duration of the interruption. For Simulations One through Five, this duration was zero to four hours. The dependent variable was the minimum effectiveness level achieved for the interruption period. Minimum effectiveness levels across Simulations Two and Six through Ten were analyzed in a polynomial regression to determine on which day the cumulative effects of the interruptions was worst as well as the minimum number of days between interruptions in which there were no compounding affects from the previous interruption. The independent variable used for this calculation was number of days between interruptions with Simulation Two being entered with zero days between interruptions and Simulations Six through Ten being one to five days between interruptions. The dependent variable was the minimum effectiveness level reached for the second interruption period.

V. RESULTS

A. PREDICTED EFFECTIVENESS AFTER SINGLE NIGHT AWAKENING

The FAST analysis results for Simulations Two through Five can be seen in Figures 12-15. Note the points of sleep interruption and the drop in effectiveness upon awakening. This point, minimum effectives, is marked with a data marker providing amplifying information.

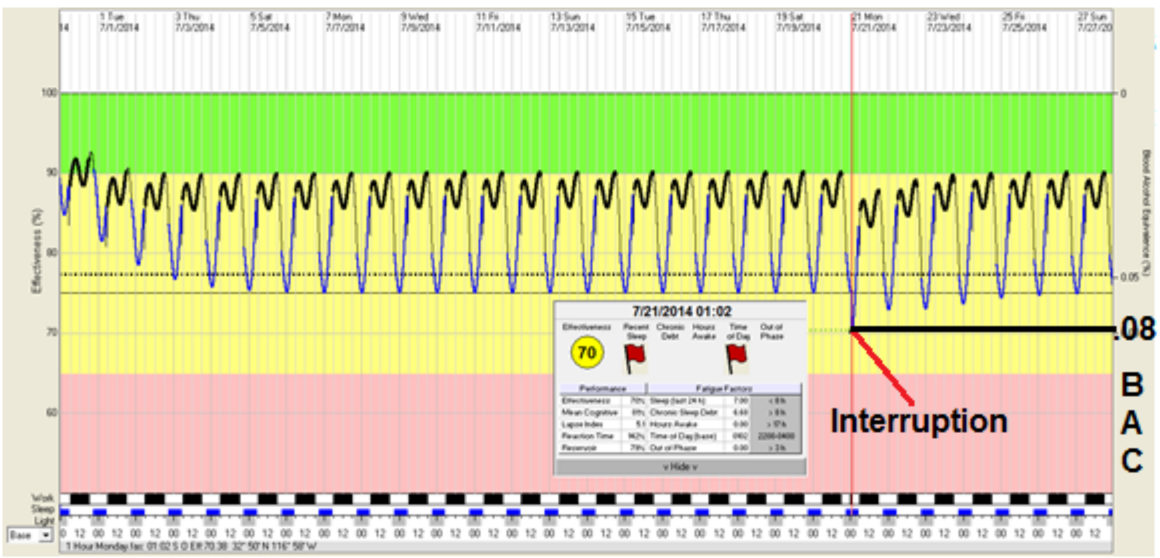

Figure 12. Simulation 2 FAST Analysis Plot.

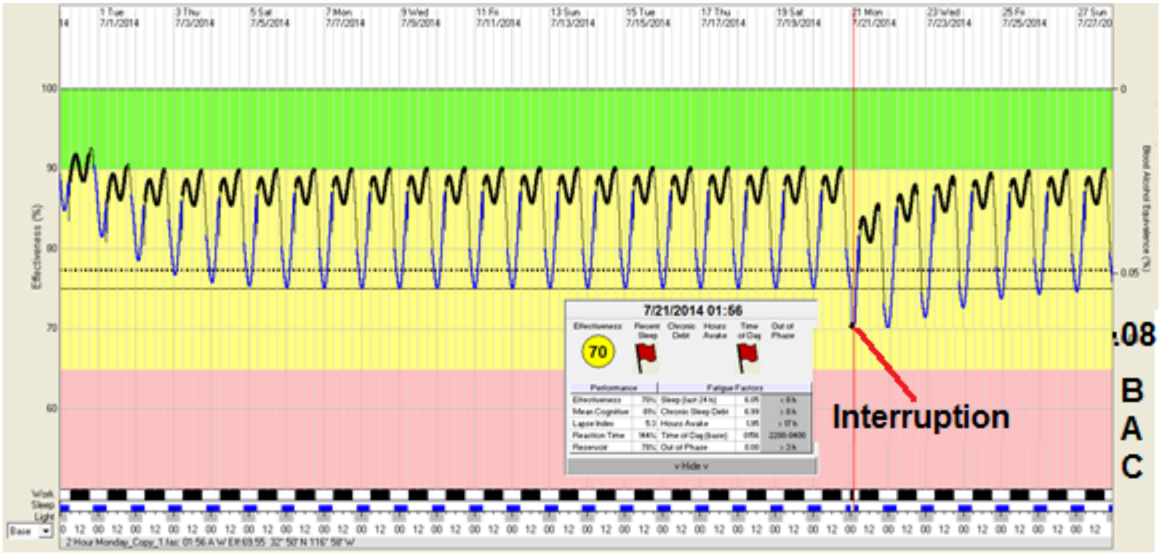

Figure 13. Simulation 3 FAST Analysis Plot.

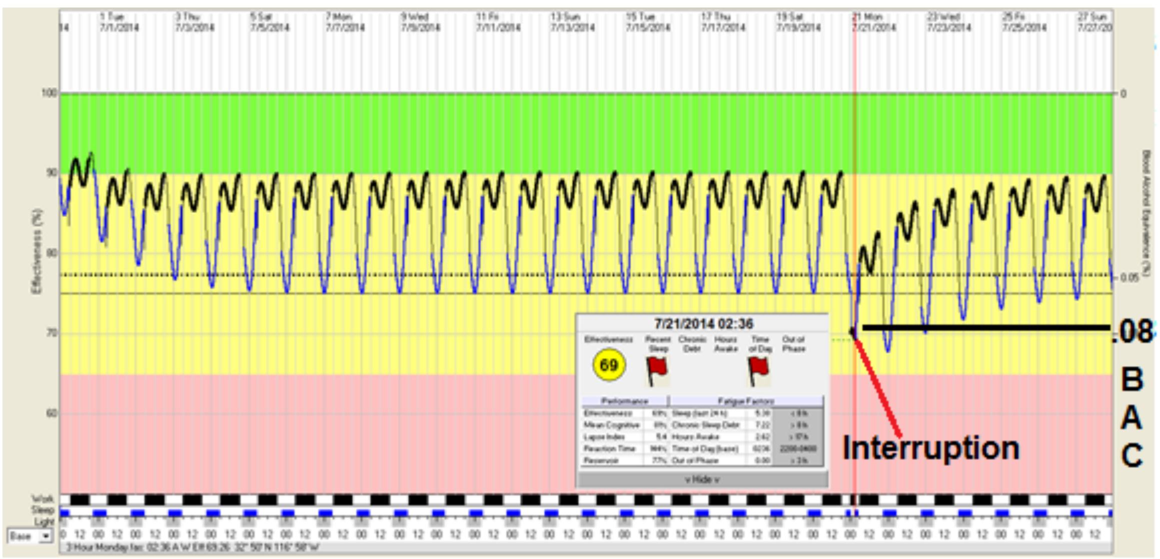

Figure 14. Simulation 4 FAST Analysis Plot.

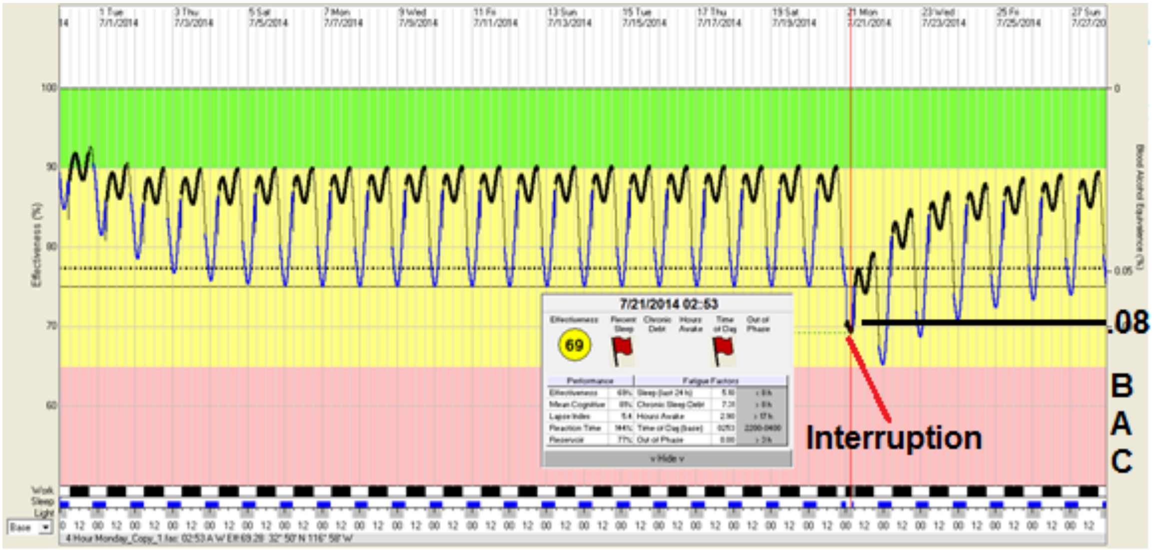

Figure 15. Simulation 5 FAST Analysis Plot.

Table 2 and Figure 16 represent the data collected from these analyses.

Table 2. Single Night Effectiveness		
Simulation #	Hours of interruption (x)	%Minimum Effectiveness (y)
1	0	75
2	1	70
3	2	70
4	3	69
5	4	69

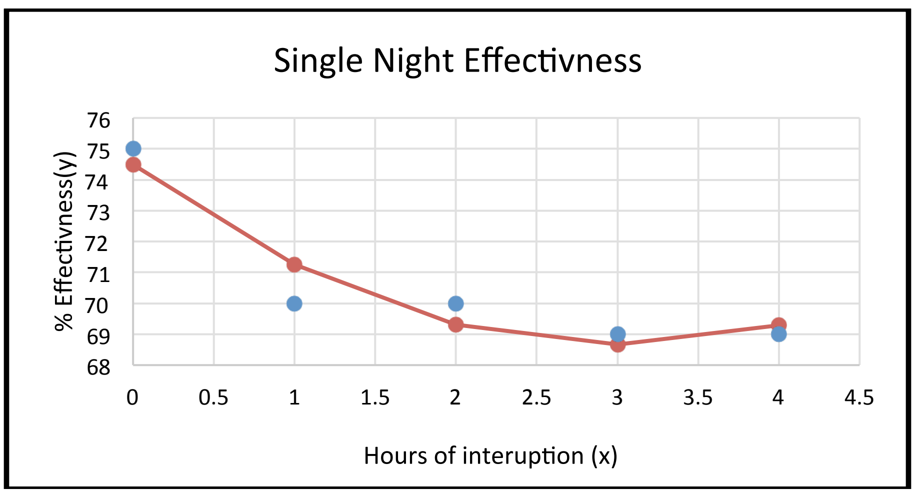

Figure 16. Single Night Effectivness Plot of Data Points and Regression

The statistical analysis of single night effectiveness levels conducted in Microsoft Excel 2013 shows that the percentage of effectiveness varies systematically with the duration of sleep interruption. The best fit model is quadratic: Yhat = 74.48+-3.87 x + .64 x^2. $R^2 = .90$, $F(2, 2) = 9.02$, $p < .05$. The linear term (-3.87) accounts for the sharp drop from zero to one hour of interruption. The quadratic term (+.64) dampens the sharp drop. Because of this effect, additional hours of interruption do not have as much effect as does the first hour. The minimum predicted effectiveness level is observed at three hours with the predicted values at two, three and four hours being essentially equal. The equation cannot be extrapolated beyond four hours of interruption. FAST reports that an effectiveness level of 70% equates to a BAC of .08. Predicted effectiveness levels drop below the 70% level, where BAC equivalent exceeds .08, at 1.55 hours of interruption.

B. PREDICTED EFFECTIVENESS AFTER MULTIPLE NIGHT AWAKENINGS

The FAST analysis results for Simulations Two through Five can be seen in Figures 17-21. Note the effect of the first interruption on the second interruption. The point of minimum effectiveness is marked with a data marker providing amplifying information.

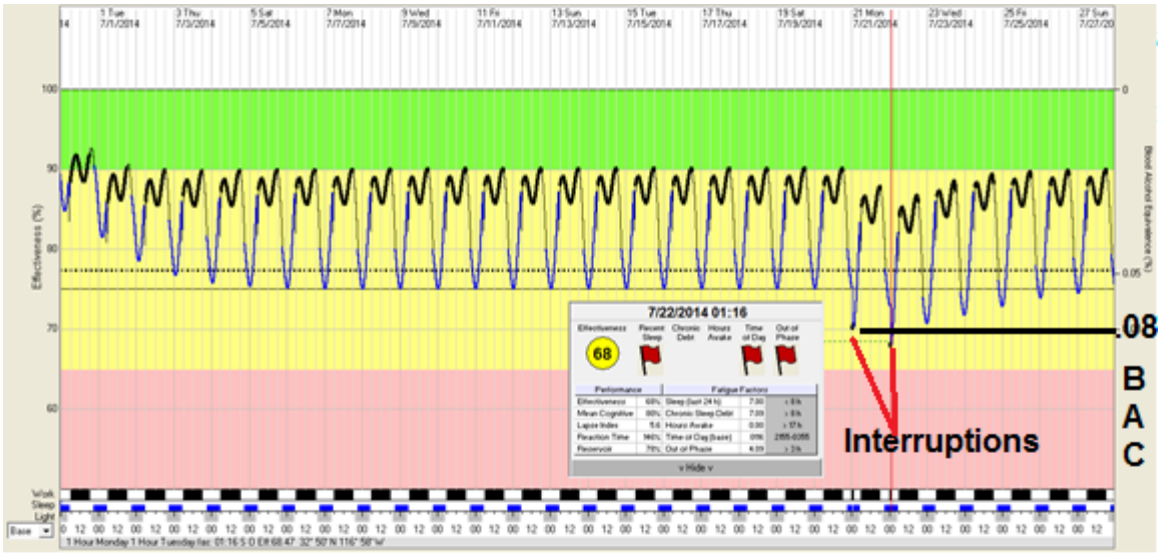

Figure 17. Simulation 6 FAST Analysis Plot.

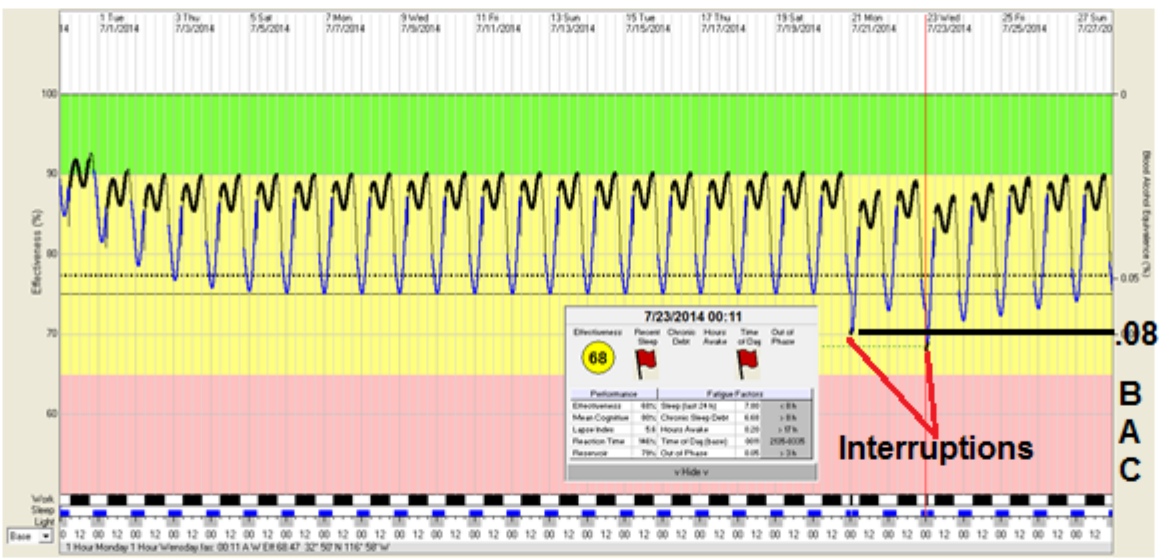

Figure 18. Simulation 7 FAST Analysis Plot.

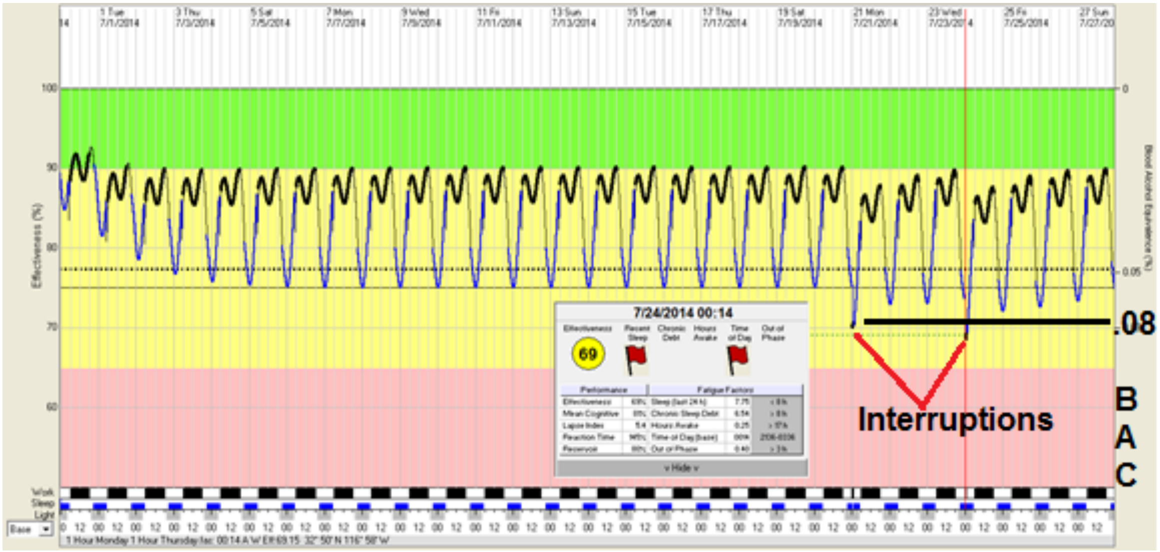

Figure 19. Simulation 8 FAST Analysis Plot.

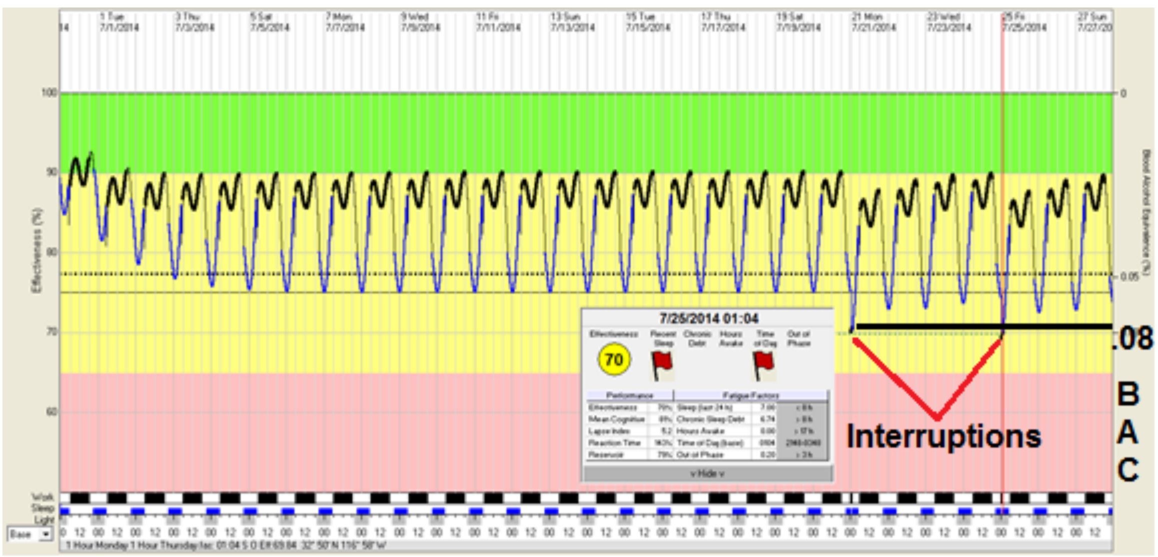

Figure 20. Simulation 9 FAST Analysis Plot.

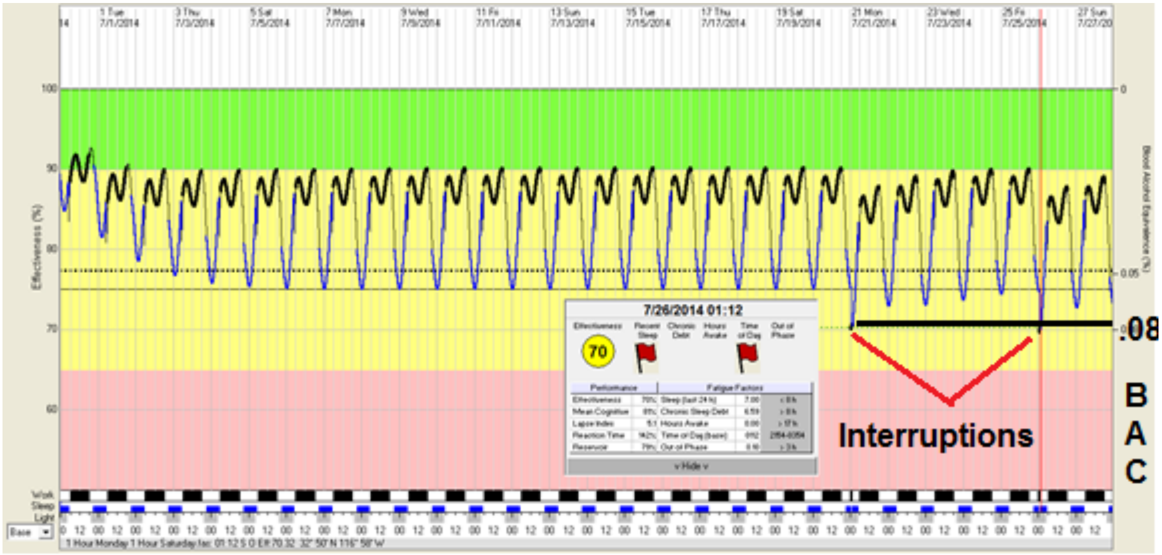

Figure 21. Simulation 10 FAST Analysis Plot.

Table 3 and Figure 22 represent the data collected from these analyses.

Table 3. Multi Night Effectiveness		
Simulation #	Days Between Interruptions (x)	%Minimum Effectiveness (y)
2	0 (M)	70
6	1 (M,T)	68
7	2 (M,W)	68
8	3 (M,TH)	69
9	4 (M,F)	70
10	5 (M,S)	70

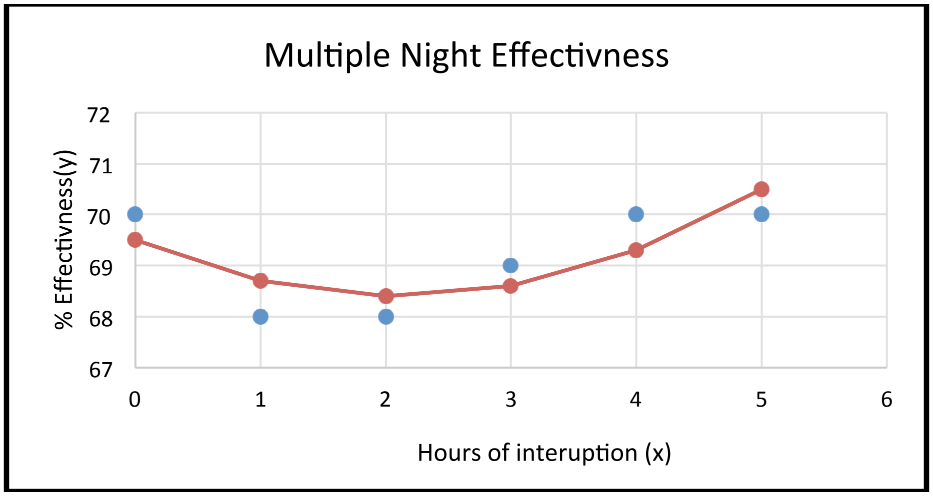

Figure 22. Multiple Night Effectivness Plot of Data Points and Regression

The statistical analysis of the multiple night effectiveness levels conducted in Microsoft Excel 2013 shows that the percentage of effectiveness varies systematically with the number of days between interruptions. The best fit model is quadratic: Yhat = 69.5+-1.05X+.25X^2. R^2 = .90, $F(2, 2) = 9.02$, $p < .05$. The linear term (-1.05) accounts for the initial decrease from zero to two days between interruptions. The quadratic term (+.25) dampens out and overcomes the negative slope, creating a positive slope after two days. Interruption effects on effectiveness levels are maximized at two days between interruptions. The lack of compounding effects from the first interruption to the second occurs four to five days between interruptions. At this point, the effects of sleep interruptions are no longer cumulative and the model is no longer valid.

VI. CONCLUSION

Interruptions to sleep have significant impacts on effectiveness. A worker who is awakened to conduct maintenance begins that work at 71% of max effectiveness and after 1.55 hours awake is operating at a predicted effectiveness level equal to that of an individual with 0.08% BAC. The impact of a single one hour sleep interruption has a residual impact to effectiveness for four to five days after the event occurs with cumulative effects peaking at two days between interruptions. The ability to maintain OPNAV 3710.7U sleep requirements for flight support personnel is critical to ensuring that safe and effective maintenance is being performed on the aircraft.

Equally important to OPNAV 3710.7U sleep requirements is the ability to maintain NAVAIR 00-80T-106 operational requirements, all of which center on a detachment's capability to operate safe and effective 24-hour continuous maintenance. To balance the domains of Human Systems Integration (HSI), primarily safety and personnel in the face of operational requirements, solutions can be found in the HSI domains of manpower, training.' and human factors engineering.

From the domain of human factors engineering, aircraft could be redesigned to reduce complexity and allow a less qualified maintainer to conduct maintenance. Such a solution would be best analyzed in a follow-on comparative study to assess the design and production costs against the projected manpower cost savings.

From the domains of manpower, personnel, and training, to increase the number of qualified personnel on detachments, squadrons could either increase training for their current manning in order to increase qualifications levels, or augment their manning to bring in more qualified personnel, or they could do both. By increasing training and raising the detachment's second worker's

qualification level to CDQAR, or at a minimum CDI, the ability to maintain 24-hour continuous maintenance would greatly increase. Workload and knowledge base would be better distributed amongst the two members of the work center and the detachment would be less dependent on a single CDQAR/CDI, eliminating a single point of failure when conducting maintenance in many circumstances. Manpower at the squadron level would need to be capable of supporting the increased training requirements while still maintaining their current detachment manning capability. A follow-on study would be required to determine if current manpower is sufficient to support both the increased training and detachment manning.

By augmenting the manpower to bring in more qualified maintainers, squadrons could staff two CDQARs, or at a minimum, one CDQAR and one CDI in each detachment work center. This adjustment would be a temporary, but not long-term, solution. Such a solution would not be viable in the long-term with a limited pool of qualified personnel from which to draw. Eventually, the surplus talent pool would be eliminated and the system would revert to its current state.

A compromise solution would be a balance between the two solutions. Manpower could be initially augmented to increase the number of qualified personnel to train the unqualified personnel and equip detachments. Once enough personnel have been trained, the system should be able to sustain itself without subsequent manpower augmentations. Such a compromise would resolve the feasibility problem of the training solution and the lack of long-term solvency in the manpower solution. A follow-on study would be required to determine the size and associated cost of the initial manpower increase.

A quantifiable problem exists for HSC detachments. Worker effectiveness at the levels predicted by FAST for sleep interruptions is unsafe for conducting maintenance. OPNAV and NAVAIR requirements cannot be maintained by the current manpower structure of detachments. Multiple solutions do exist but each

one needs further research to determine their viability. Until these issues are addressed at the OPNAV/PERS level, the interim recommendations based on this study that can be implemented at the squadron and detachment level are:

a) Only interrupt OPNAV sleep requirements in emergency situations when the consequences of not doing so outweigh the safety risk associated with decreased maintainer effectiveness;

b) Allow at a minimum four to five days of full eight hour sleep periods for recovery to eliminate compounding effects.

Remember: safety first, mission always.

VII. LIST OF REFERENCES

Department of the Navy. (2013a). *COMNAVAIRFORINST 4790.2B The Naval Aviation Maintenance Program (NAMP).* Patuxent River, MD: Naval Air Systems Command

Department of the Navy. (2009). OPNAVINST 3710.7U NATOPS General Flight and Operating Instruction. Department of the Navy Issuances Web site http://doni.daps.dla.mil/.

Department of the Navy. (2013b). NAVAIR 00-80T-106 LHA/LHD NATOPS Manual. Patuxent River, MD: Naval Air Systems Command

Fatigue Avoidance Scheduling Tool (FAST) version 3.2.01. (2014). Nova Scientific Corporation. http://www.novasci.com

Microsoft Office Excel. (2013). Microsoft Corporation. http://office.microsoft.com/en-us/excel